2.4 PLUTONIUM DISPOSITION ALTERNATIVES AND RELATED ACTIVITIES

As described in Section 2.1.4, nine alternatives, which can be grouped into three categories, were identified as reasonable for disposition of Pu. The three categories and the alternatives within them are as follows:

Deep Borehole Category

- *Direct Disposition Alternative*—direct emplacement to deep boreholes without immobilizing Pu forms

- *Immobilized Disposition Alternative*—immobilization of Pu forms without adding radionuclides and then emplacement into deep boreholes

Immobilization Category

- *Vitrification Alternative*—immobilization of Pu in a glass matrix with processing in a vitrification facility and then dispose in a HLW repository[16]

- *Ceramic Immobilization Alternative*—immobilization of Pu in a ceramic matrix with processing in a ceramic immobilization facility and then dispose in a HLW repository[16]

- *Electrometallurgical Treatment Alternative*—immobilization of Pu in a GBZ form in an electrometallurgical treatment facility and then dispose in a HLW repository[16]

Reactor Category

- *Existing LWR Alternative*—convert Pu into MOX fuel, use MOX fuel in existing LWRs, and then dispose of spent fuel in an HLW repository[16]

- *Partially Completed LWR Alternative*—convert Pu into MOX fuel, use MOX fuel in partially completed LWRs, which are completed under this program, and then dispose of spent fuel in a HLW repository[16]

- *Evolutionary LWR Alternative*—convert Pu into MOX fuel, use MOX fuel in evolutionary LWRs, and then dispose of spent fuel in a HLW repository[16]

- *CANDU Reactor Alternative*—convert Pu into MOX fuel, use MOX fuel in Canadian CANDU reactors, and then dispose of spent fuel in the Canadian spent fuel program

Preferred Alternative for Pu Disposition: A combination of reactor and immobilization alternatives. The Preferred Alternative calls for (1) immobilizing at least those Pu materials not readily suitable for MOX fuel using vitrification or ceramic immobilization and (2) converting pure Pu metal, including pits, and oxides into MOX fuel for use in existing reactors. Use of Canadian CANDU reactors would be retained in the event that a multilateral agreement is made among Russia, Canada, and the United States to implement this.

The number of years a specific facility is expected to operate is based on facility sizing and throughput capacities. Preconstruction activities would require about 5 years for all the alternatives.[17] Preconstruction activities for the deep borehole category may take longer and may require additional legislation and associated

[16] See Appendix H (appropriate regulatory section) for a discussion of how the NWPA, as amended, might apply for disposal in a HLW repository.

[17] Preconstruction activities include tests, demonstrations, licenses, and tiered NEPA activities.

regulations. About another 5 years would be required for construction, startup, preoperational testing, and operational readiness review for all the alternatives. Construction of completely new reactors or deep boreholes could take longer. The time required for operations of all alternatives will vary depending on the amount of Pu material remaining after stabilization activities and the size, number, and throughput capacities of disposition facilities. If one of the domestic Reactor Alternatives were chosen, the MOX-based spent nuclear fuel is assumed to remain in the spent fuel pool for up to 10 years before relocation to a HLW repository. If either of the Deep Borehole Alternatives were chosen, the time to emplace the surplus Pu would depend on the number of deep boreholes being drilled. For each alternative, if decontamination and decommissioning (D&D) is proposed in the future, such activities are estimated to require up to 5 years for all but MOX fuel fabrication and reactors, which could take up to 10 years. D&D would not be proposed for the borehole sites, but for long-term institutional control (for future deterrence), the Deep Borehole Alternatives would likely take longer. D&D, if proposed, would be preceded by appropriate NEPA analysis.

As the various disposition technologies evolve and are refined through further study, development, and design, processes and facility arrangements would be optimized. This optimization would include specific operational relationships of facilities common to the selected alternatives, such as pit disassembly/conversion and Pu conversion facilities. Because this refinement process is ongoing, information and data presented in the technical documents for some of the alternatives are updated from that which was initially presented in the data reports supporting this PEIS. However, this PEIS considers the updated information as well. [Text deleted.]

Each of the nine disposition alternatives can be implemented in a number of ways because each alternative merely defines the generic technology approach used to achieve the Spent Fuel Standard. For example, using different numbers of existing reactors to accomplish the mission or utilizing different Pu concentrations within a borosilicate glass formulation represent variations for the existing reactor and vitrification alternatives, respectively. Determining which of the many possible variants to analyze within the PEIS is a matter of engineering judgment. A list of possible variants to the nine disposition alternatives is shown in Table 2.4–1.

[Text deleted.]

Representative facility locations for analyzing Pu disposition alternatives at Hanford, NTS, INEL, Pantex, ORR, and SRS are shown in Figures 2.4–1 through 2.4–6. These locations include those for the pit disassembly/ conversion, Pu conversion, vitrification, ceramic immobilization, MOX fuel fabrication, and evolutionary LWR facilities. Locations for the deep borehole complex, commercial MOX fuel fabrication facility, and existing LWRs, are generic. At ORR, the representative site for the evolutionary LWR is on undeveloped land (see Figure 2.4–5). This site is not within the ORR boundary, but is owned by the Tennessee Valley Authority (TVA). A previous agreement between DOE and TVA has reserved the site for a nuclear application, and it is anticipated that the land area would be transferred from TVA to DOE. The Bellefonte Nuclear Plant, approximately halfway between Huntsville, Alabama, and Chattanooga, Tennessee, is the representative analysis site for the partially completed reactor alternative. INEL is the representative site for the Electrometallurgical Treatment Alternative. For the CANDU Reactor Alternative, the Bruce-A Nuclear Generating Station is the representative site for the analysis. The following sections describe the requirements for each disposition technology listed above.

[Text deleted.] Three Immobilization Alternatives and three reactor alternatives produce a waste form that could be suitable for disposal in a domestic HLW repository. Such a repository, if approved under the provisions of the NWPA and its amendments, would serve as the disposal site for commercial and DOE-owned spent nuclear fuel and HLW. DOE is currently characterizing the Yucca Mountain site for the repository. If the Secretary of Energy recommended the Yucca Mountain site for the repository, the recommendation would be accompanied by an EIS (the repository EIS), the NOI for which was published on August 7, 1995 (60 FR 40164). DOE completed scoping in Fiscal Year 1996 and will continue working the EIS given sufficient appropriations. The Yucca Mountain site has not yet been recommended by the President and approved by Congress; therefore, this Storage and Disposition PEIS does not analyze impacts to a repository. No waste forms are currently licensed for disposal

Table 2.4–1. Descriptions of Variants to Analyzed Disposition Alternatives

Alternatives	Possible Variants
• Deep borehole direct disposition	• Arrangement of Pu in different types of emplacement canisters.
• Deep borehole immobilized disposition	• Bucket emplacement of pellet-grout mix. • Pumped emplacement of pellet-grout mix. • Pu concentration loading, size and shape of ceramic pellets.
• New vitrification facilities	• Collocated pit disassembly, Pu conversion, and immobilization facilities. • Use of either Cs-137 from capsules or HLW as a radiation barrier. • Wet or dry feed preparation technologies. • An adjunct melter adjacent to the DWPF at SRS, in which borosilicate glass frit with Pu (without highly radioactive radionuclides) is added to borosilicate glass containing HLW from the DWPF. • A can-in-canister approach at SRS in which cans of Pu glass (without highly radioactive radionuclides) are placed in DWPF canisters which are then filled with borosilicate glass containing HLW in the DWPF (See Appendix O). • A can-in-canister approach similar to above but using new facilities.
• New ceramic immobilization facilities	• Collocated pit disassembly, Pu conversion, and immobilization facilities. • Use of either Cs-137 from capsules or HLW as a radiation barrier. • Wet or dry feed preparation technologies. • A can-in-canister approach at SRS in which the Pu is immobilized without highly radioactive radionuclides in a ceramic matrix and placed in which are then placed in the DWPF canisters that are then filled with borosilicate glass containing HLW (see Appendix O). • A can-in-canister approach similar to above but using new facilities.
• Electrometallurgical treatment (glass-bonded zeolite form)	• Immobilize Pu into metal ingot form. • Locate at DOE sites other than ANL-W at INEL.
• Existing LWR with new MOX facilities	• Pressurized or Boiling Water Reactors. • A different number of reactors. • European MOX fuel fabrication. • Modification/completion of existing facilities for MOX fuel fabrication. • Collocated pit disassembly/conversion, Pu conversion, and MOX fuel facilities. • Reactors with different core management schemes (Pu loadings, refueling intervals).
• Partially completed LWR with new MOX facilities	• Same as for existing LWR (except that MOX fuel would not be fabricated in Europe).
• Evolutionary LWR with new MOX facilities	• Same as for partially completed LWR.
• CANDU reactor with new MOX facilities	• A different number of reactors. • Modification/completion of existing facilities for MOX fabrication. • Collocated pit disassembly/conversion, Pu conversion, and MOX facilities. • Reactors with different core management schemes (Pu loadings, refueling intervals).

in a HLW repository. For the Immobilization Alternatives, legislative clarification or NRC determination by rule may be required before the immobilized Pu can be placed in an NWPA repository. Data to estimate waste forms under consideration in this PEIS for disposal in a repository are compared to data currently being evaluated for disposal in a NWPA-licensed repository. The results of this analysis are in Appendix H.

The fourth Reactor Alternative would use surplus U.S. Pu in MOX fuel for Canadian reactors, with the spent nuclear fuel managed by Canada. The MOX-based spent nuclear fuel from the alternative would be comparable to spent fuel from ongoing power producing operations in that country. This PEIS presents an analysis of domestic activities within the continental United States. A brief impact assessment of activities in Canada is included in Appendix I.

DOE would analyze the impacts of continued storage of immobilized Pu waste forms or MOX-based spent nuclear fuel in a tiered NEPA document under any of the following conditions: (1) if the DOE HLW Program changes its approach for disposal of commercial spent nuclear fuel, (2) if the timeframe for acceptance of waste by the program is significantly delayed beyond current projections, or (3) if the Pu immobilized waste forms or MOX-based spent nuclear fuel resulting from Pu disposition alternatives are not acceptable to a licensed repository.

Six DOE sites and other generic and specific sites were used for assessing the environmental impacts of various disposition technologies and strategies. The locations of the new facilities considered for the various disposition technologies are representative and for analysis purposes only. Until tiered NEPA documentation has been completed, no specific location within any specific site (or sites) will be selected for any disposition alternative action.

This Storage and Disposition PEIS assumes all surplus Pu could be processed through each of the various disposition technology alternatives. However, some surplus Pu material may not be suitable for processing under every disposition technology. As a result, the strategy for disposition of surplus Pu could involve a combination of disposition alternatives. In addition, if any of the LWR alternatives are selected, there is also a multipurpose reactor variant (see Section 1.4 and Appendix N) that could produce tritium, use Pu as fuel, and in some designs generate revenue through the sale of electricity.

No Plutonium Disposition Action

As discussed in Section 1.6, a "No Pu Disposition" action means disposition would not occur, and surplus Pu-bearing weapon components (pits) and other forms, such as metal and oxide, would remain in long-term storage in accordance with decisions on the long-term storage of Pu.

Activities Common to Multiple Plutonium Disposition Alternatives

As previously described, the disposition alternatives for surplus Pu involve a variety of technologies. However, two activities are common to all the disposition alternatives, including the Preferred Alternative:

- Pit disassembly/conversion
- Pu conversion

Since these common activities involve the conversion of surplus Pu from current forms to one suitable for disposition, they are essential components of each disposition alternative. Pit disassembly and Pu conversion facilities could be collocated. Multiple facilities located at the same site are analyzed in Section 4.7.3, and more specific analysis will be performed in tiered NEPA documents, as appropriate.

Upon completion of the pit disassembly/conversion and/or Pu conversion processes, the Pu materials would be ready for further actions under one or more of the disposition technology alternatives.

2.4.1 PIT DISASSEMBLY/CONVERSION FACILITY

The pit disassembly/conversion facility would be common to all disposition alternatives, including the Preferred Alternative. The facility would disassemble, reshape, and convert the pits into an unclassified metal or oxide form usable by the next facility in the disposition process. In addition, some non-pit material (such as pure Pu metal) may be processed at the pit disassembly/conversion facility. The material contained in the pit disassembly/conversion facility, would require the highest levels of protection.

In accordance with the Preferred Alternative for surplus Pu disposition, the pit disassembly/conversion facility could be located at either Hanford, INEL, Pantex, or SRS. Further tiered NEPA review will be conducted to examine alternative locations, including new and existing facilities, at these four sites should the Preferred Alternative be selected at the ROD.

Facility Description. The surplus Pu would be removed from the pits by separating them in half with a cutting wheel and subjecting each half to a dry chemical process that converts the metal to a hydride powder, then either back to metal or to an oxide powder. Figure 2.4.1–1 depicts the material flow through the facility.

The total disturbed land area for the operating facility would be approximately 12 hectares (ha) (30 acres), plus a 1.6-kilometer (km) (1-mile [mi]) buffer zone around the operating facility. Provisions would be included to accommodate future international treaty requirements for inspection. Figure 2.4.1–2 shows a conceptual site layout perspective.

[Text deleted.] Appendix B provides a more detailed breakdown of the key buildings required at the pit disassembly/conversion facility. These buildings and their missions include the following:

Plutonium Processing Building. Pits would be disassembled, and the Pu and other components would be separated in this building. All wastes would be processed here for disposal. In addition, the building would contain maintenance facilities, laboratories, utility systems, heating ventilation and air conditioning (HVAC) equipment, and other support functions.

Administration Building. Management offices, meeting and conference rooms, a visitor control office, and the cafeteria would be contained here.

Plutonium Operations Support Building. Change rooms, decontamination facilities, offices, maintenance shops, operator training rooms, process demonstration laboratories, and general storage areas would be located in this building.

Warehouse. This building would provide miscellaneous storage and general delivery areas.

Utilities Building. Steam and water treatment facilities, the plant air system, and the chilled water system would be located in this building.

Generator Building. Emergency generators would be located in this building.

Guard and Vehicle Monitoring Station. This building would serve as the pedestrian and vehicle entrance to the facility. A hardened guard booth and a vehicle entrance lane next to the pedestrian entrance would be provided.

Facility Operations. Wherever possible, operations would be conducted by automated and robotic systems to reduce personnel exposure. The facility would be designed for a throughput of 3.25 t (3.58 tons) of Pu per year, using two shifts per day, 5 days per week. Surge capability would be provided by increasing plant personnel and adding weekend work shifts.

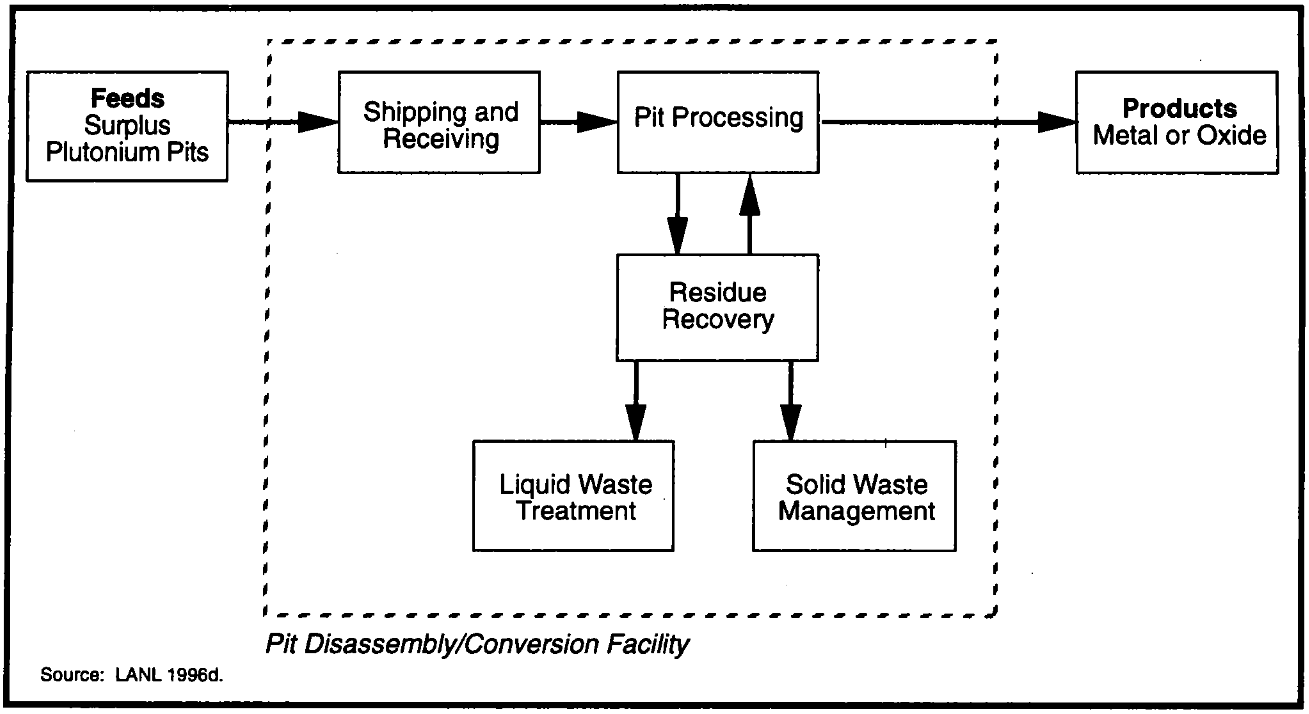

Figure 2.4.1–1. Pit Disassembly/Conversion Facility Material Process Flow.

The pit disassembly/conversion facility would contain all required systems to remove Pu from weapons components and to package the material into an unclassified form suitable for shipment to the next facility in the disposition process. Operational flow within the facility would be through several main processing areas. Shipping and receiving would handle the incoming pit inspection, decontamination, storage, and initial processing and the outgoing shipping functions for the Pu metal or oxide produced by the facility. Pit disassembly and conversion operations[18] would process the pit mechanically and chemically within gloveboxes into either Pu metal or oxide (depending upon the selected disposition process) and would package it for removal. Another output of the process would be waste, both liquid and solid, consisting of low-level, TRU, hazardous, and mixed waste. An analytical laboratory would be required to perform Pu assays on product and waste streams as well as to certify waste streams. A lag storage vault would be used to store product metal or oxide, uranium forms, and other components before packaging for shipment to the next disposition facility. Utilities and manpower resources needed during operation are presented in Appendix C. Chemicals required during operations can be found in the classified appendix. The water balance is depicted in Appendix D.

Construction. Construction of the facility would take approximately 6 years and have a peak annual employment of 125 construction workers. Construction of the pit disassembly/conversion facility would require an additional 2 ha (5 acres) of land for construction laydown, warehousing, and construction parking. Resources consumed during construction are shown in Appendix C.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap metal before construction was completed. The remaining nonhazardous wastes generated during construction would be disposed of by the contractor as part of the construction project. Uncontaminated

[18] The Department is developing ARIES to remove Pu from weapons pits and convert it into either an oxide or metal. This prototype program is intended to demonstrate a completely integrated process to disassemble and convert pits into an unclassified metal or oxide form that would be usable in the next disposition process facility.

wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes such as adhesives, oils, and solvent rags would be packaged in DOT-approved containers and shipped to offsite commercial RCRA-permitted treatment, storage, and disposal facilities. No soil contaminated with hazardous or radioactive constituents is expected to be generated during construction. However, if any was generated, it would be managed in accordance with site practice and all Federal and State standards.

Operation of the pit disassembly and conversion facility would generate TRU, low-level, hazardous, mixed, and nonhazardous wastes. The conceptual design includes waste management facilities that would treat and package all waste generated into forms that would enable staging and/or disposal in accordance with RCRA and other applicable statutes. TRU and mixed TRU waste would be treated and packaged to meet the WIPP WAC. These wastes would be stored awaiting shipment to a Federal repository (assumed to be WIPP, depending on decisions resulting from the supplemental EIS for the proposed continued phased development of WIPP for disposal of TRU waste). LLW would be treated and packaged to meet the waste acceptance criteria of an onsite or offsite DOE LLW disposal facility. The DOE LLW disposal facility that would be used would be consistent with decisions resulting from the Waste Management PEIS and tiered NEPA documents. Mixed LLW would be treated and disposed in accordance with the respective site treatment plan that was developed to comply with the *Federal Facility Compliance Act*. Hazardous wastes would be packaged in DOT-approved containers and shipped to RCRA-permitted treatment and disposal facilities. Liquid nonhazardous wastes such as sanitary, utility, and process wastewater would be treated and discharged in accordance with the site practice. Treated wastewater would be reclaimed to use as makeup water when economically and/or environmentally desirable. Solid nonhazardous waste would be disposed of in permitted landfills and recycled, as appropriate. [Text deleted.]

Transportation. Intrasite transportation of all the receiving, storage, and processing activities would be contained within the facility. Transfers within the processing building would be through tunnels or secure transfer hallways. Material would be moved between process areas by carts, forklifts, or a conveyer system. Upon receipt, material would go either directly into the process lines or into lag storage, depending on the amount of material received and the status of the processing areas. After processing is complete, the material would be placed in lag storage before being sent to the next facility in the disposition process.

For offsite transfers, the organization initiating action for the material would have the ultimate responsibility for its safe transfer from the time the material is offered for transportation until it is received at the final destination. Shippers, transporters, and receivers are responsible for compliance with applicable transportation requirements. Destination of the products would depend on the disposition alternatives that are chosen. Transportation data can be found in Appendix G.

2.4.2 PLUTONIUM CONVERSION

For all the surplus Pu disposition alternatives, including the Preferred Alternative, Pu not processed at the pit disassembly/conversion facility would be processed at the Pu conversion facility. This facility would convert non-pit, surplus Pu into metal or oxide suitable for use at the next disposition facility in the process. Most, if not all, of the Pu material in the scope of the Storage and Disposition program is assumed to be in the *Criteria for Safe Storage of Plutonium Metal and Oxides* (DOE-STD-3013-94) stabilized form prior to disposition activities. However, a small amount of material consisting of metals, oxides, and alloys may need additional processing. Such materials would be converted in this facility for subsequent disposition. The facility would also provide lag storage for some materials to be converted. Figure 2.4.2–1 depicts the material flow through the facility.

In accordance with the Preferred Alternative for surplus Pu disposition, the Pu conversion facility could be located at either Hanford or SRS. Further tiered NEPA review will be conducted to examine alternative

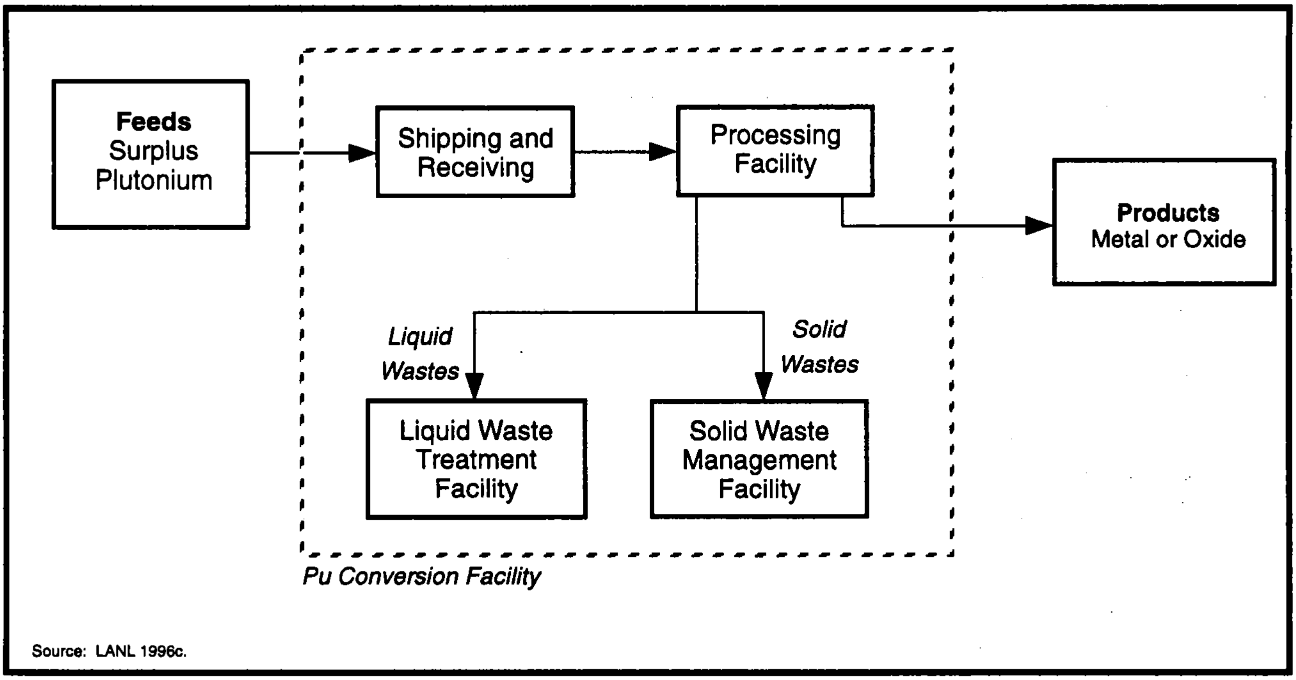

Figure 2.4.2–1. Plutonium Conversion Facility Material Flow Diagram.

locations, including new and existing facilities, at these two sites should the Preferred Alternative be selected at the ROD.

Facility Description. The material contained in the Pu conversion facility would require the highest levels of protection, including a 1.6-km (1-mi) buffer zone around the operating facility. Personnel security programs would require badging and access control of all personnel. For a new facility, the total disturbed land area would be approximately 28 ha (70 acres). Figure 2.4.2–2 depicts the conceptual site layout. Appendix B provides a more detailed description of key Pu conversion facility buildings. The mission of these buildings is as follows:

Central Warehouse, Shipping and Receiving Building. Packaging, safety confirmation of containers from the lag storage vault, and truck loading functions would be provided here. Services include unloading feed from transports, removing items from the shipping containers, confirming the contents, and handling abnormally sized packages.

Staging/Storage Facility. The interface between receiving and processing, and repackaging and storage functions would be provided in this building. These functions characterize, verify, and prepare the feeds and products for lag storage and control the flow and quality of material into and out of the glovebox operations.

Processing Building. Handling and processing Pu into a form acceptable for the next facility in the disposition process would occur here. This building would also provide utility support functions, MC&A, safety systems, waste management, repackaging, and assay and analysis.

Facility Operations. The Pu conversion facility conceptual design assumes that scrap and surplus Pu materials are pretreated to meet DOE interim storage and DOT shipping regulations. [Text deleted.] The facility design is flexible and provides for additional or reduced processing with minor process changes, such as increasing metal dissolution capacity for conversion to oxide, adding americium extraction, oxidation furnaces, or nitrate processing to meet additional alternative feed pretreatment requirements as feed forms and quantities are better defined. The Pu conversion facility would process Pu to a form that meets nuclear fuels feed or immobilization feed criteria. The facility design would be based on an annual throughput rate of 0.4 t (0.44 tons) of Pu, using one 10-hour shift, 200 days per year. Surge capability would be provided by increasing personnel and adding work shifts. Utilities and manpower resources needed during operations are presented in Appendix C. The water balance is depicted in Appendix D. Chemicals required during operations can be found in the Classified Appendix.

Construction. The construction of the Pu conversion facility would take approximately 6 years and have a peak annual employment of 358 construction workers. For a new facility, additional land area required temporarily for construction is projected to be approximately 8 ha (20 acres). This provides for construction material laydown, warehousing, and parking. Other resources consumed during construction are shown in Appendix C.

Waste Management. The solid and liquid nonhazardous wastes generated during construction would include concrete and steel construction waste materials and sanitary wastewater. The steel construction waste would be recycled as scrap metal before construction was completed. The remaining nonhazardous wastes generated during construction would be disposed of by the contractor as part of the construction project. Uncontaminated wastewater would be used for soil compaction and dust control, and excavated soil would be used for grading and site preparation. Wood, paper, and metal wastes would be shipped offsite to a commercial contractor for recycling. Hazardous wastes such as adhesives, oils, and solvent rags would be packaged in DOT-approved containers and shipped to offsite commercial RCRA-permitted treatment, storage, and disposal facilities. No soil contaminated with hazardous or radioactive constituents is expected to be generated during construction. However, if any were generated, it would be managed in accordance with site practice and all Federal and State standards.

Operation of the Pu conversion facility would generate TRU, low-level, hazardous, mixed, and nonhazardous wastes. The conceptual design includes waste management facilities that would treat and package all waste generated into forms that would enable staging and/or disposal in accordance with the RCRA and other applicable statutes. TRU and mixed TRU waste would be treated and packaged to meet the WIPP WAC. These wastes would be stored awaiting shipment to a Federal repository (assumed to be WIPP, depending on decisions resulting from the supplemental EIS for the proposed continued phased development of WIPP for disposal of TRU waste). LLW would be treated and packaged to meet the WAC of an onsite or offsite DOE LLW disposal facility. The DOE LLW disposal facility that would be used would be consistent with decisions resulting from the Waste Management PEIS and tiered NEPA documents. Mixed LLW would be treated and disposed in accordance with the respective site treatment plan which was developed to comply with the *Federal Facility Compliance Act*. Hazardous wastes would be packaged in DOT-approved containers and shipped to RCRA-permitted treatment and disposal facilities. Liquid nonhazardous wastes such as sanitary, utility, and process wastewater would be treated and discharged in accordance with the site practice. Treated wastewater would be reclaimed to use as makeup water when economically and/or environmentally desirable. Solid nonhazardous waste would be disposed of in permitted landfills and recycled, as appropriate.

Transportation. Intrasite transportation of radiological and hazardous materials would be between the Pu processing and manufacturing building and the Pu storage building. The storage container packages would be transported between vault storage and staging buildings via a hardened transfer corridor. Primary containers that have failed in storage or require intensive testing would be transported to Pu processing and manufacturing.

For offsite transfers, the organization initiating action for the material would have the ultimate responsibility for its safe transfer from the time the material is offered for transportation until it is received at the final destination. Shippers, transporters, and receivers would be responsible for compliance with applicable transportation requirements. Destination of the products would depend on the disposition alternatives that are chosen. Transportation data can be found in Appendix G.